

FAN-RELATED RESEARCH AT CMAG

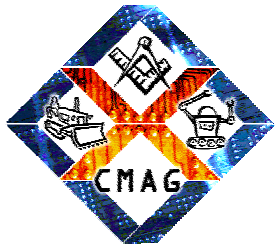
Alan Lytle

Construction Metrology and Automation Group

William Stone, Kam Saidi, Gerry Cheok, Nick Scott

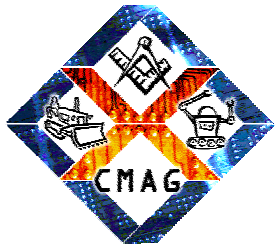
Intelligent Systems Division

Adam Jacoff, Rick Norcross, Brian Weiss



OVERVIEW

- **CMAG Introduction**
- **Automated Steel Construction Testbed**
 - **RFID / Laser Tracking / LADAR Imaging**
- **Ad-Hoc Wireless IP Tracking**
- **UWB Tracking**

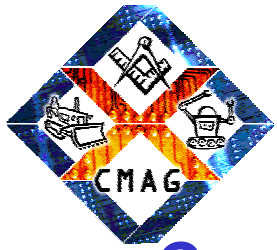


CONSIAT

Construction Integration and Automation Technologies

OBJECTIVE

To provide measurement systems, and protocols, and standards to integrate and automate the construction and design process as part of integrated and automated capital project delivery, enabling industry to achieve design and construction and design cycle-time and cost reductions.



CONSIAT

Construction Integration and Automation Technologies

- 861-4106 Performance of Innovative Technologies for Automated Steel Construction
- 861-4103 Measurement Processes and Metrics for Construction Component Tracking
- 861-4104 Field Sensor Data and Construction Process Integration Interface Protocols
- 861-4101 Systems Integration and Performance Analysis for Next Generation LADAR
- 861-4102 Construction Object Recognition
- 861-4100 Metrics for LADAR Range Imaging and Registration
- 861-4109 Design and Construction of a LADAR Calibration Facility
- 863-5016 Product Data Standards for Steel Construction
- 863-5292 Interoperability Standards for Capital Facilities – Improving Equipment
Design, Specification, Purchase, Fabrication, and Installation
- 860-1018 Economic Analysis of Construction Industry Institute Benchmarking Data
- 860-1298 Interoperability Cost Analysis of the U.S. Construction Industry

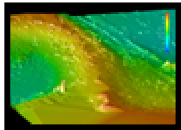


CONSIAT

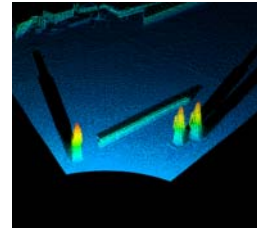
Construction Integration and Automation Technologies



Field Sensor Data

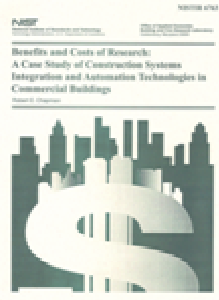
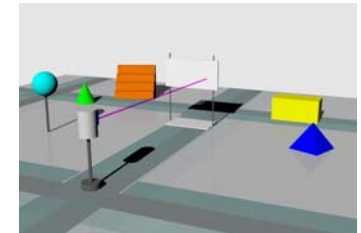


Object Recognition



Metrics for LADAR Range Imaging and Registration

LADAR Calibration Facility

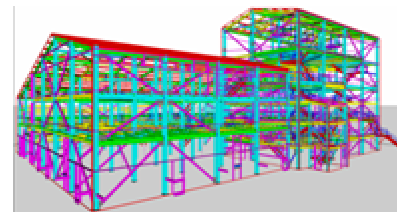
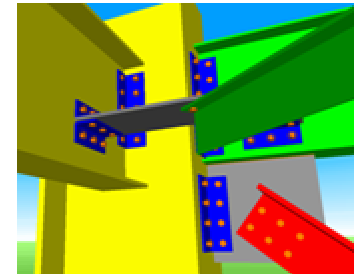


Product Data Standards

Interoperability Standards

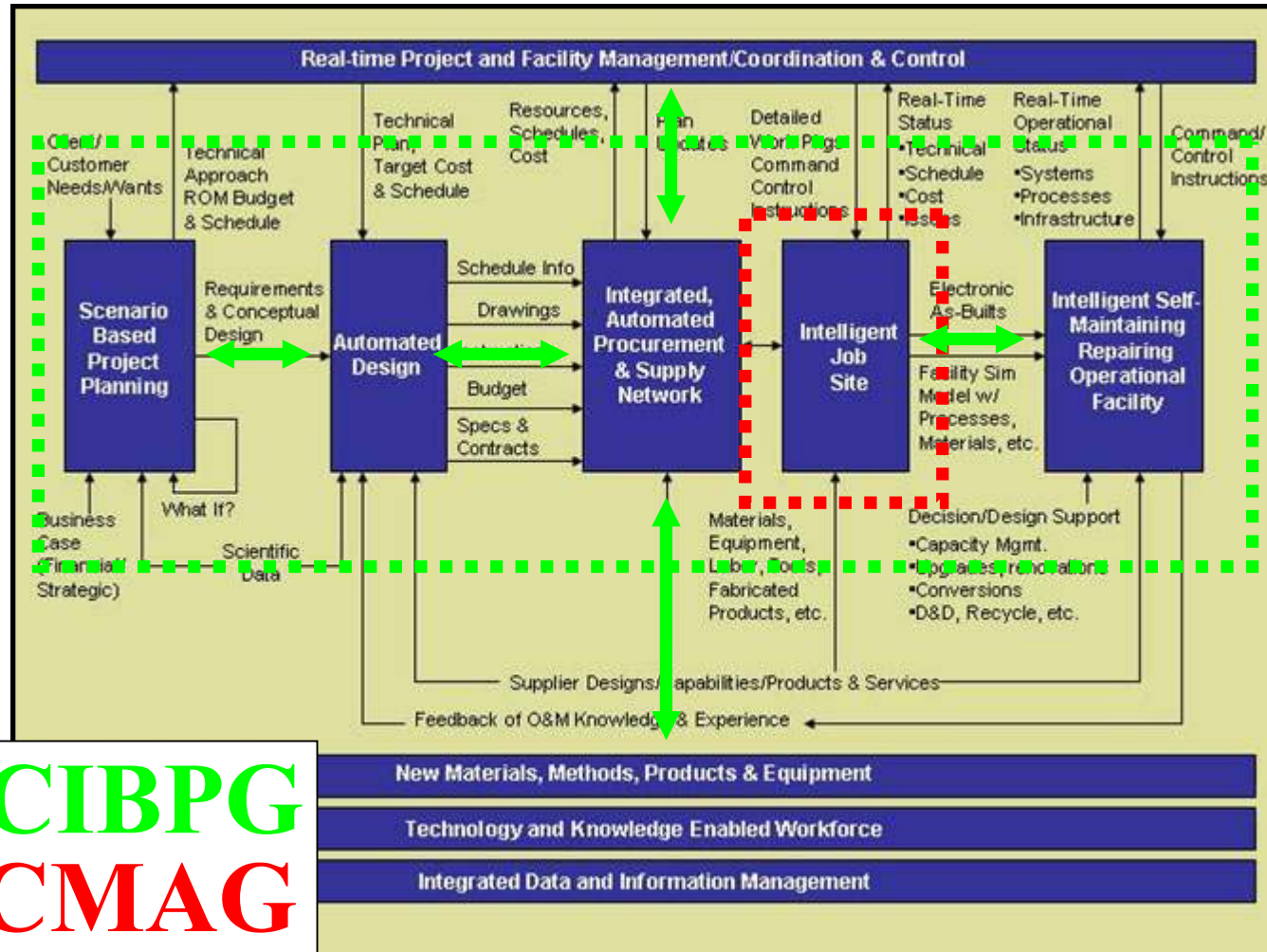
Economic Analysis

Interoperability Cost Analysis



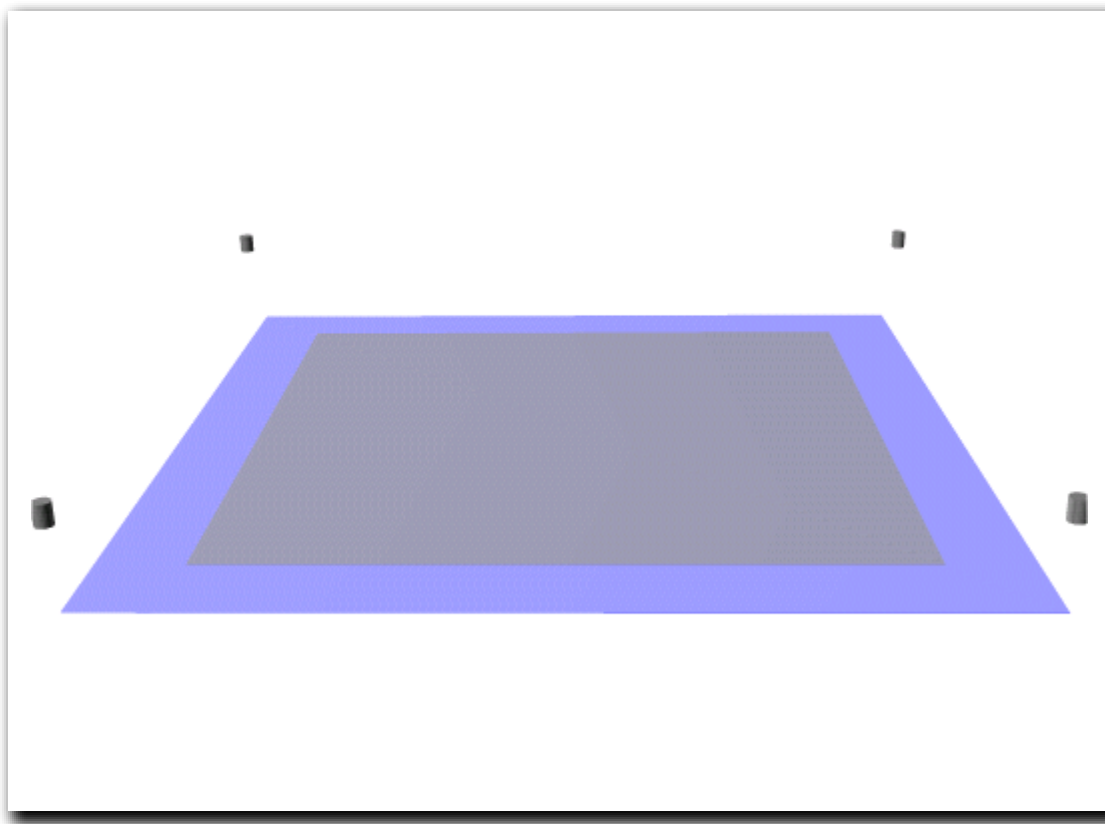


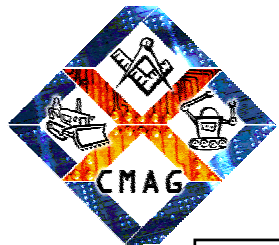
CIBPG
CMAG



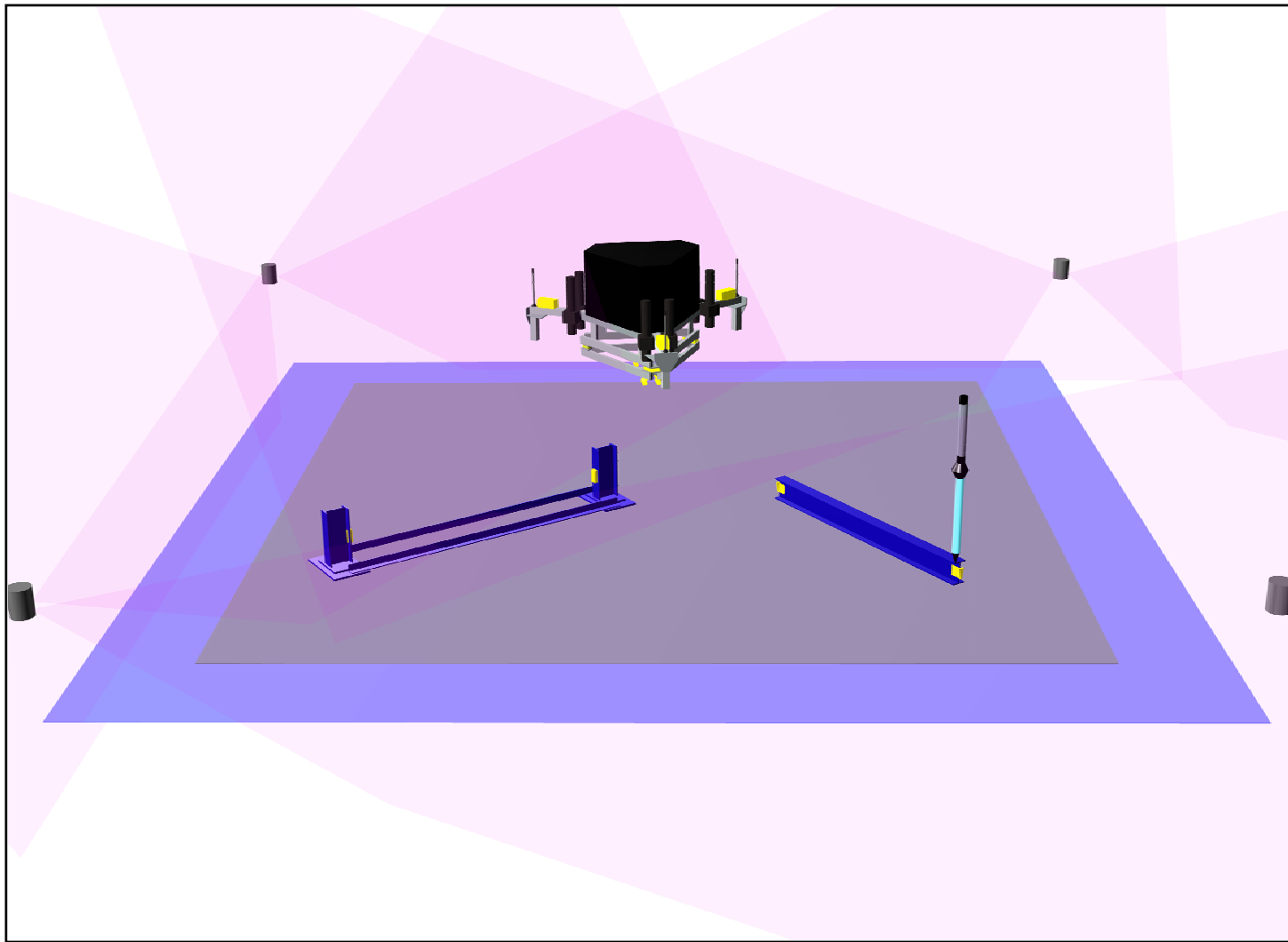


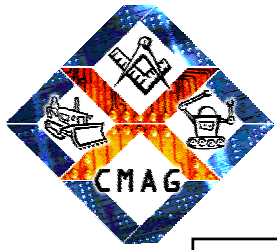
AUTOMATED STEEL CONSTRUCTION TESTBED



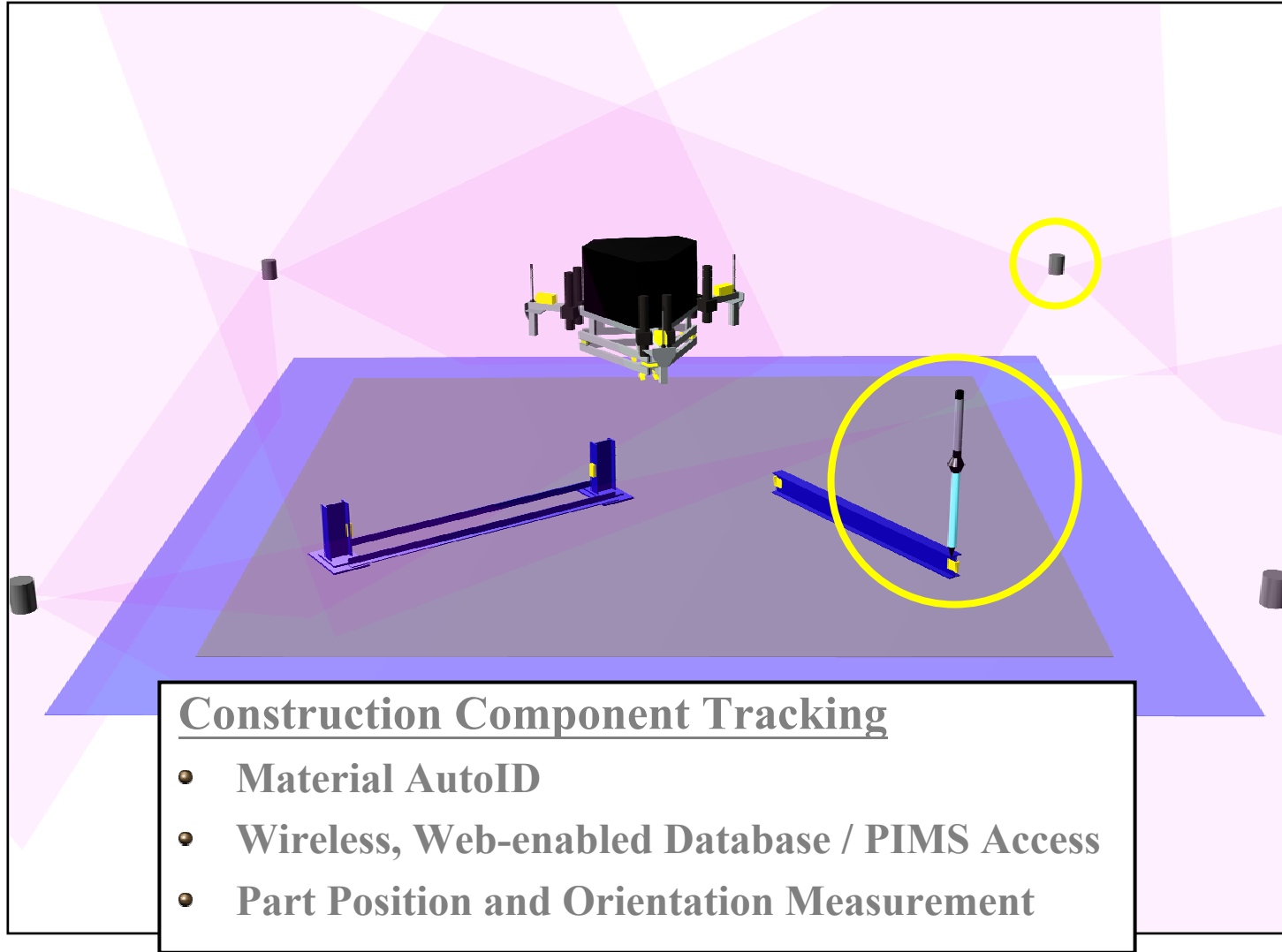


ASC TESTBED





ASC TESTBED



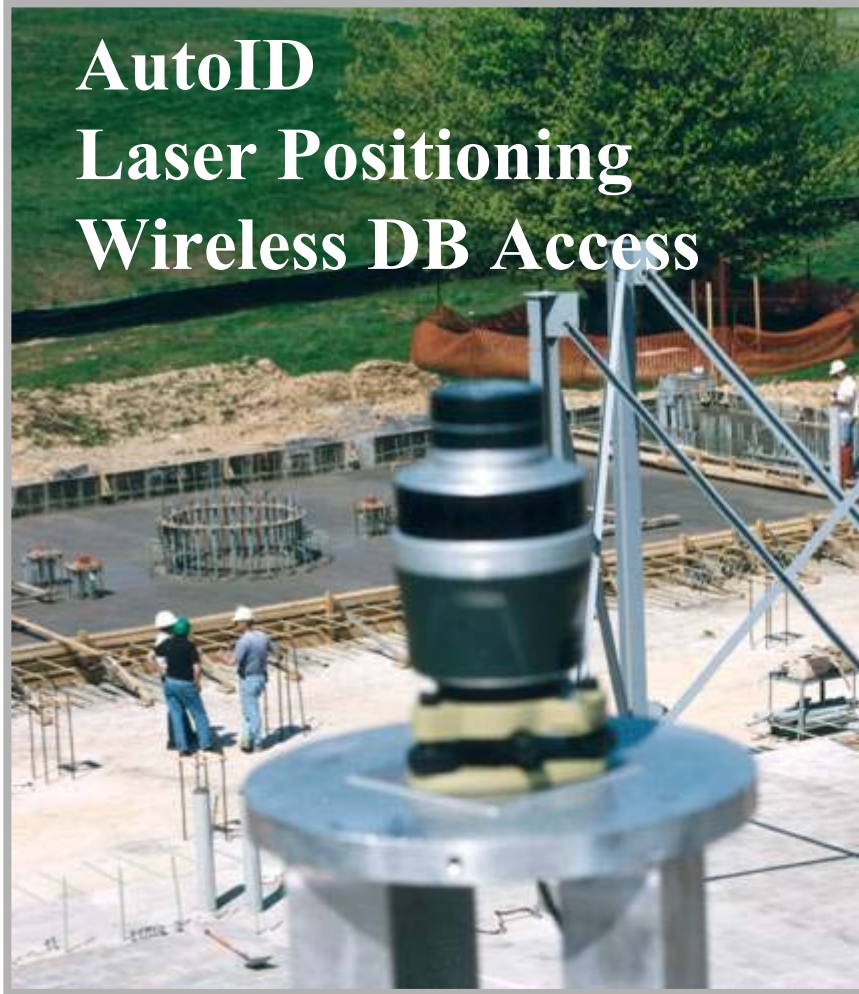
Construction Component Tracking

- Material AutoID
- Wireless, Web-enabled Database / PIMS Access
- Part Position and Orientation Measurement



NIST Comp-TRAK

AutoID
Laser Positioning
Wireless DB Access





SITE MEASUREMENT SYSTEM

OI



Laser Transmitter



Computer Board



Photo Courtesy Arc Second, Inc.

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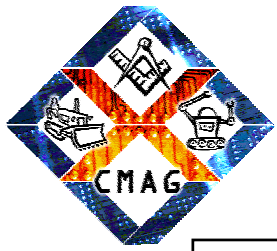


SITE MEASUREMENT SYSTEM

Angle Measurement



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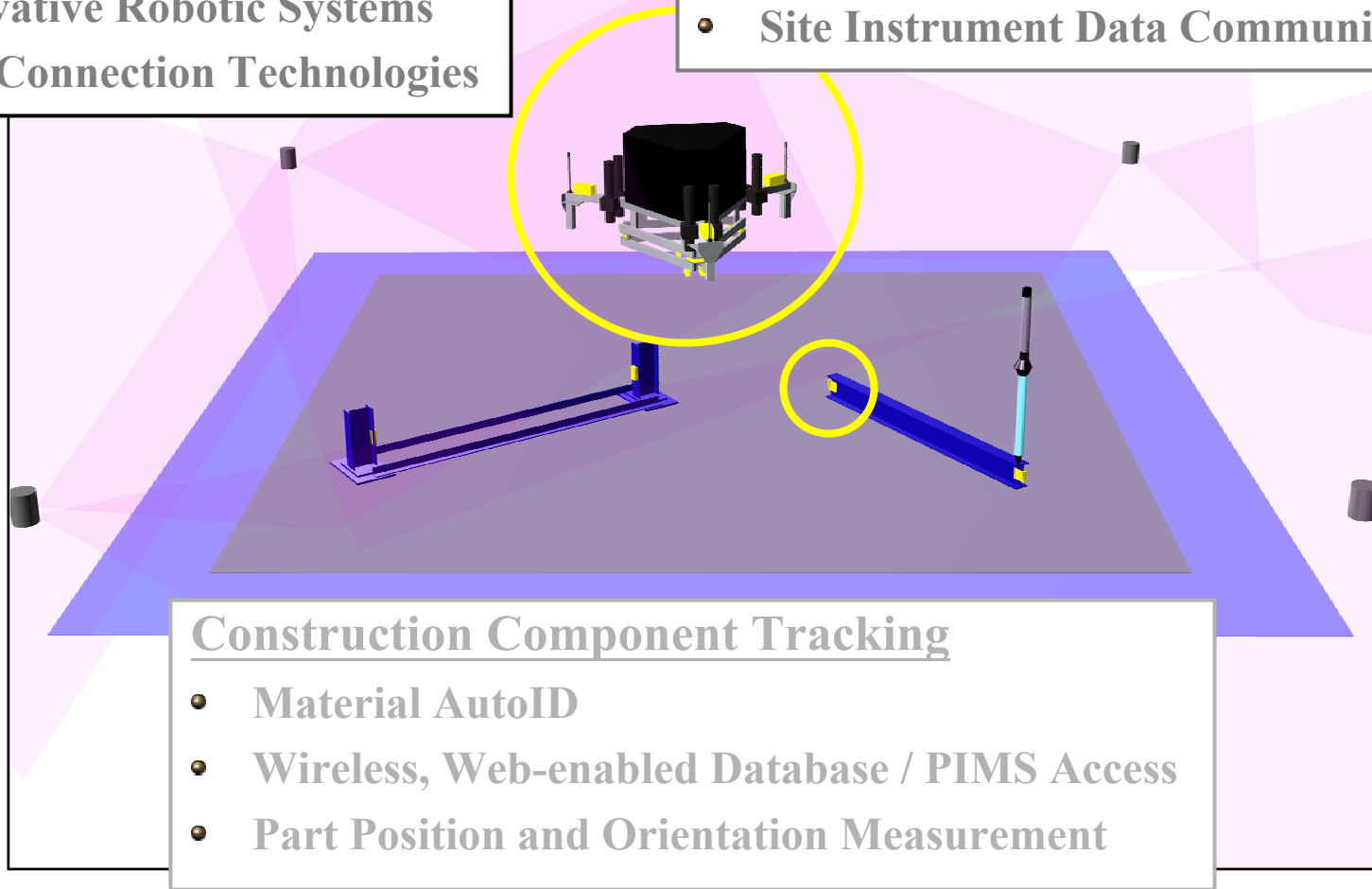
ASC TESTBED

Automated Steel Construction

- Innovative Robotic Systems
- New Connection Technologies

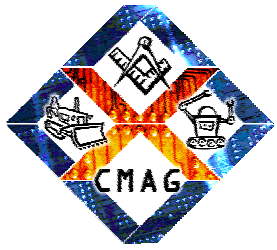
Field Sensor Data / Interface Protocols

- Material / Trades Tracking
- Site Instrument Data Communication



Construction Component Tracking

- Material AutoID
- Wireless, Web-enabled Database / PIMS Access
- Part Position and Orientation Measurement



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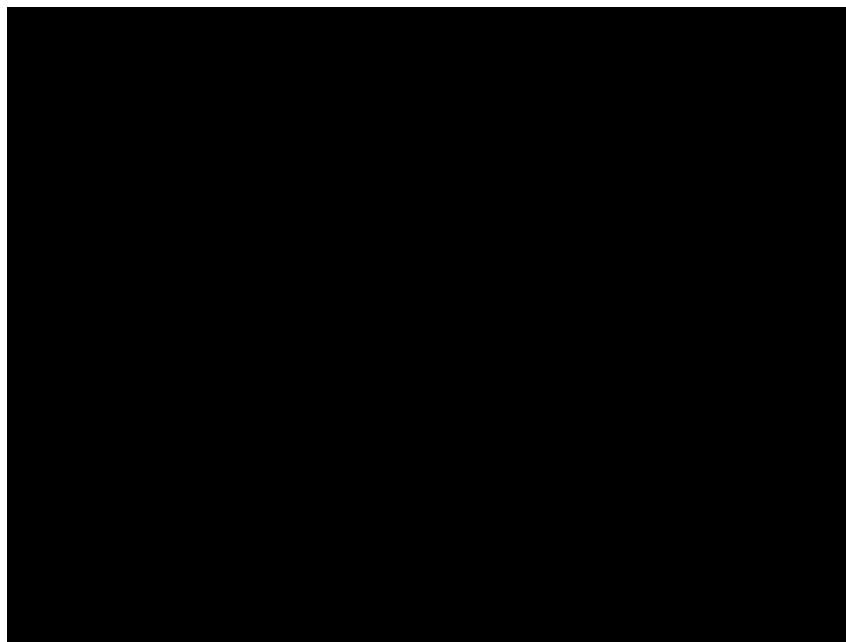
FY03 Accomplishments

- **Combined**
 - RoboCrane 6 DOF Manipulator
 - Real-Time Laser Positioning for robot tracking in 6DOF
 - Comp-TRAK part pose measurement
 - Automated beam gripper mechanism
 - Assembly scripts from commercial 4D CAD package
- **Demonstrated**
 - Multiple component pick and place with 4D CAD generated assembly sequence





ASC TESTBED



Video accelerated 5X



SOLVING AUTO-PLACEMENT

Learning from Autonomous Mobility



HMMWV



XUV



ADVANCED CRANE CONTROL

Learn from Autonomous Mobility



Army Research Laboratory

Demo III Tactical Readiness Level 6 Testing

Evaluation Autonomous Mobility performance
in a “representative environment”



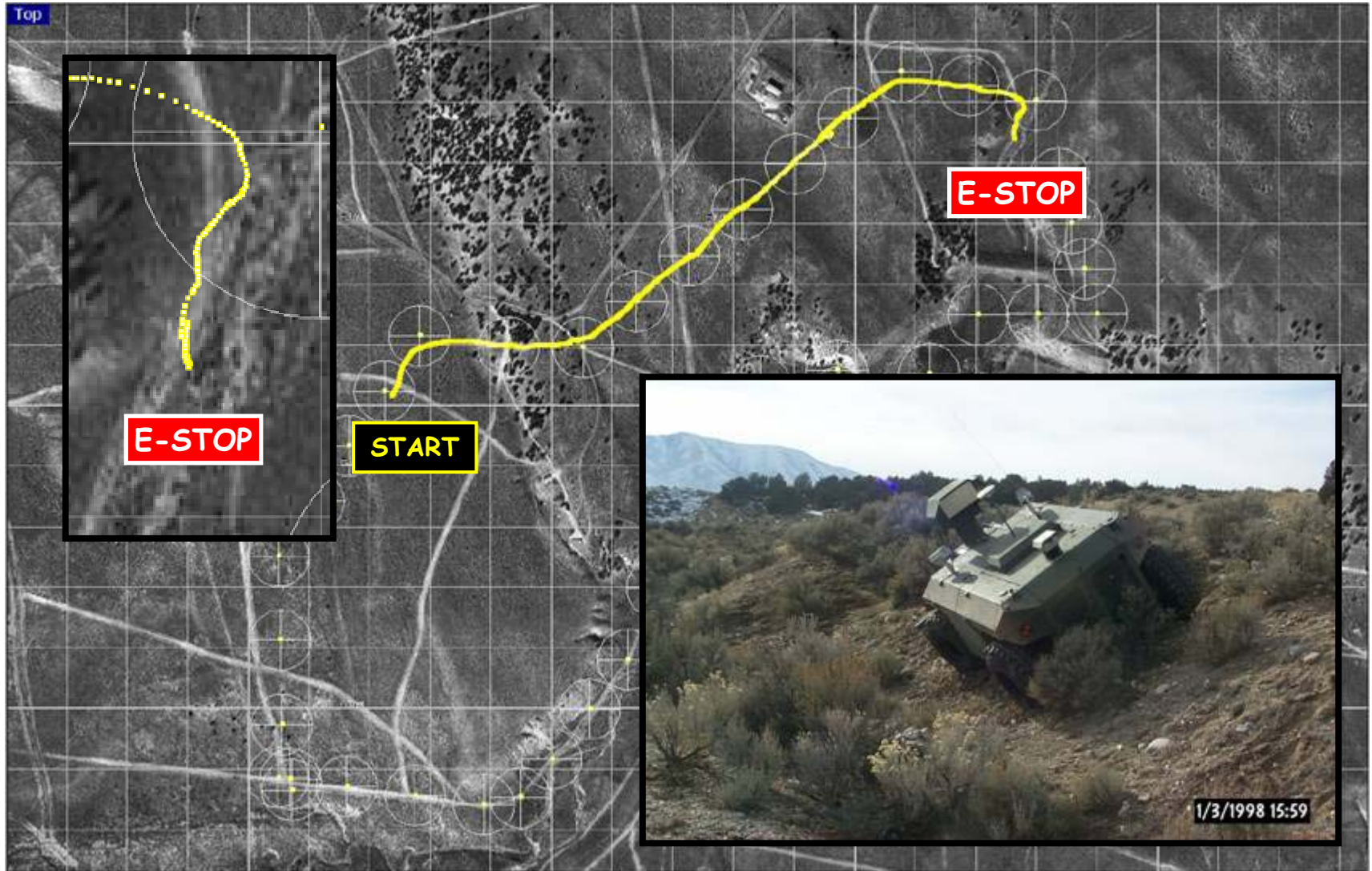
- **THREE SITES**
 - Arid (Tooele, UT)
 - Rolling Hills / Vegetative Cover (FTIG, PA)
 - Urban (FTIG, PA)



**GENERAL
DYNAMICS**
Robotic Systems

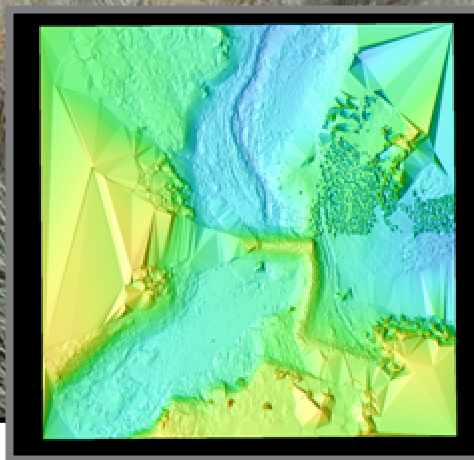
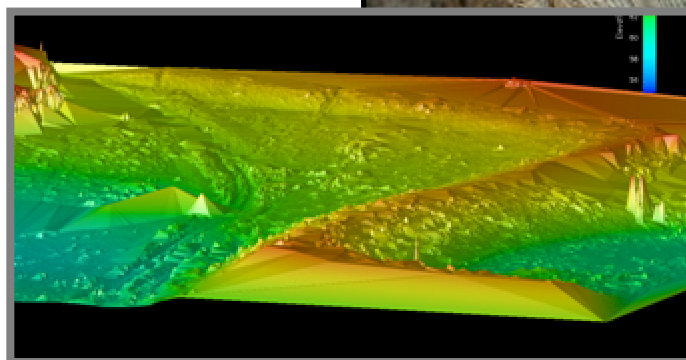
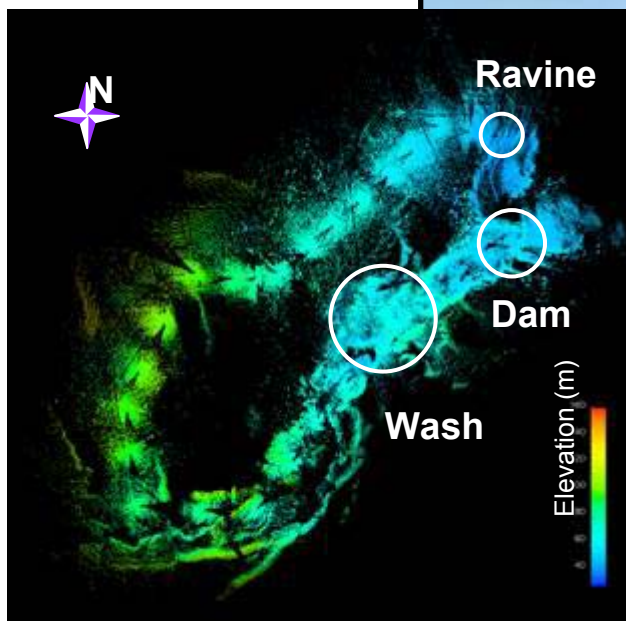


TRL-6 TESTING





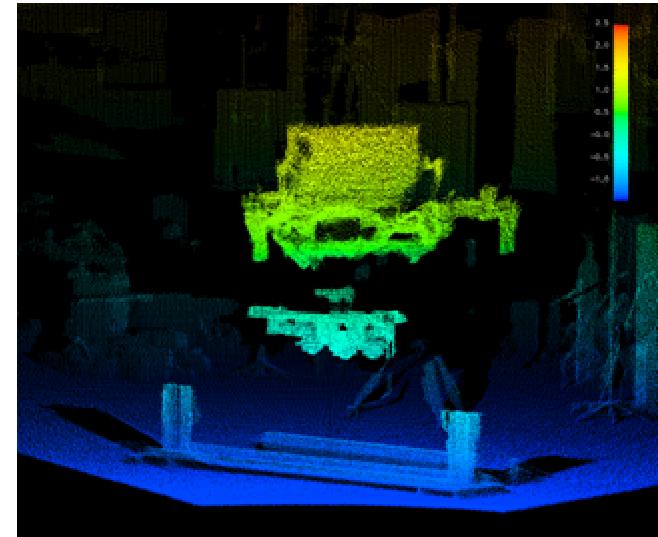
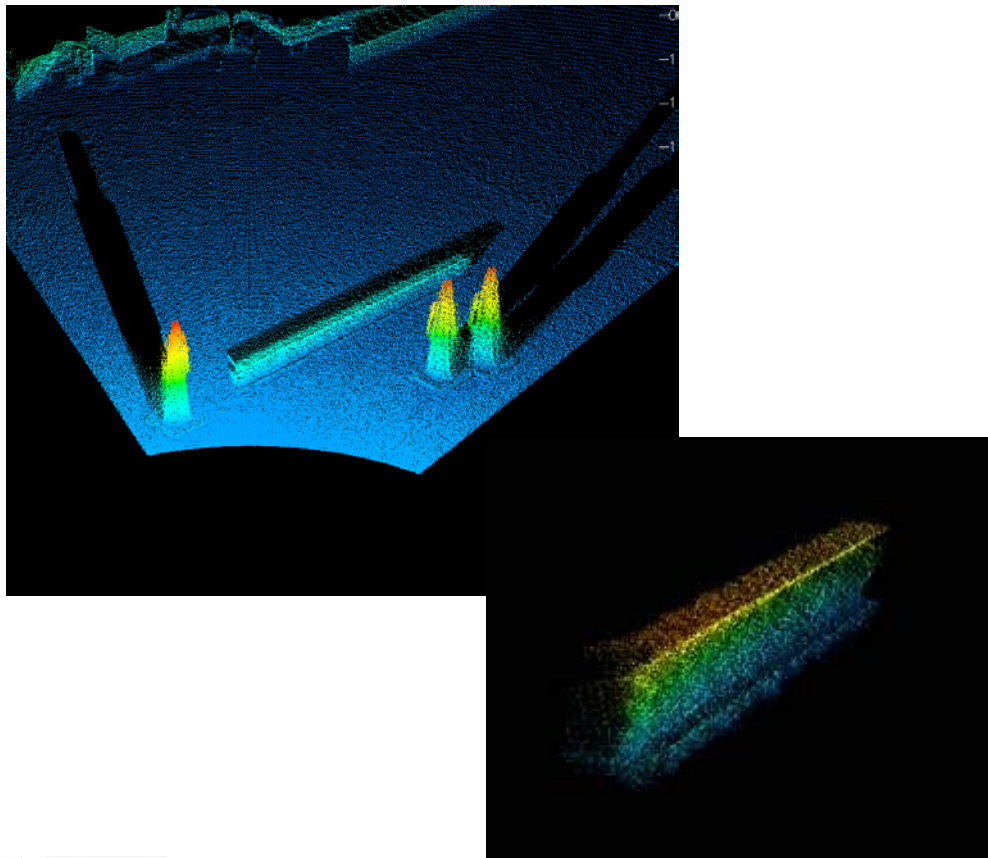
TERRAIN “AS-BUILT”





APPLICATION TO ASCT

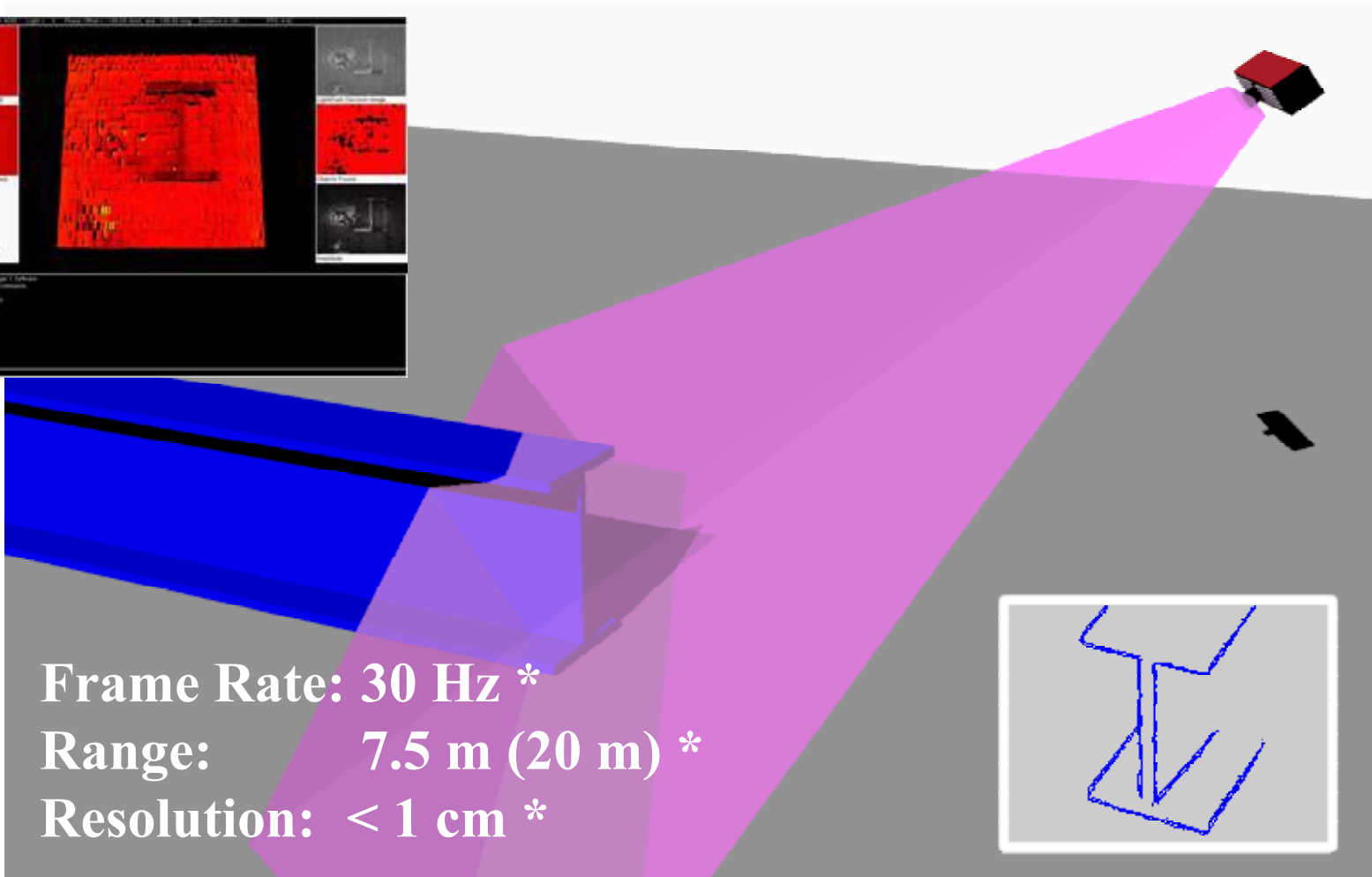
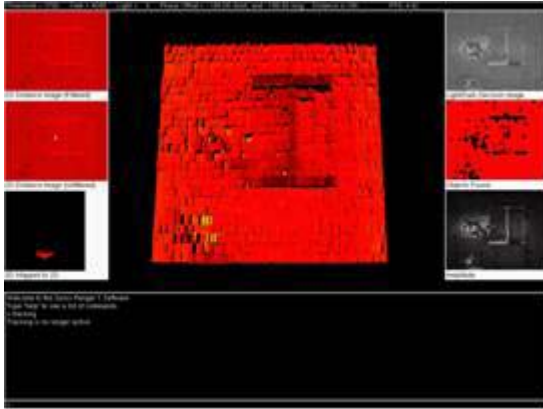
- “Truth Model” for path planning
- Combine with RFID to trim component search field



- Create “work surfaces”
- Pinpoint target locations in structure and then track crane/payload to those positions.



CSEM FLASH LADAR

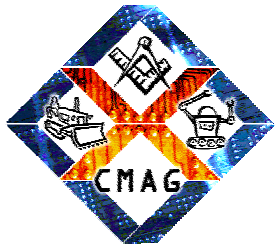


Frame Rate: 30 Hz *

Range: 7.5 m (20 m) *

Resolution: < 1 cm *

*** Manufacturers Specification**



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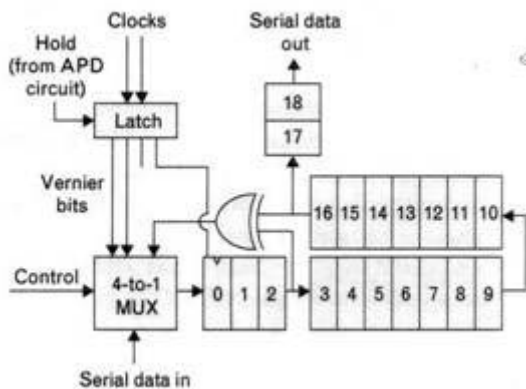
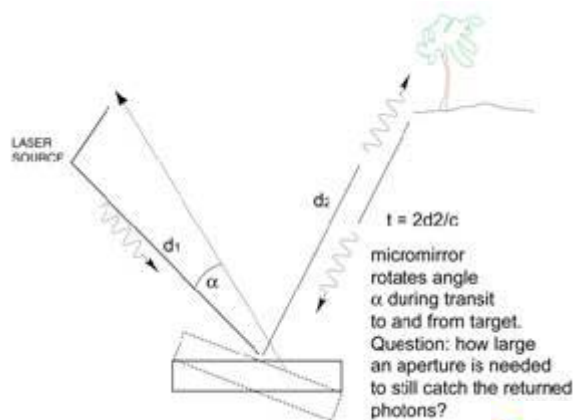
Future Efforts – FY04



- Improve real-time tracking and control
- High frame-rate (fast) LADAR for obstacle avoidance and payload delivery
- High resolution (slow) LADAR for as-built information



Next Generation LADAR



Fast LADAR at NIST:

FANDANGO:

Fast Angular Deflection
Experiment At NIST.GOV

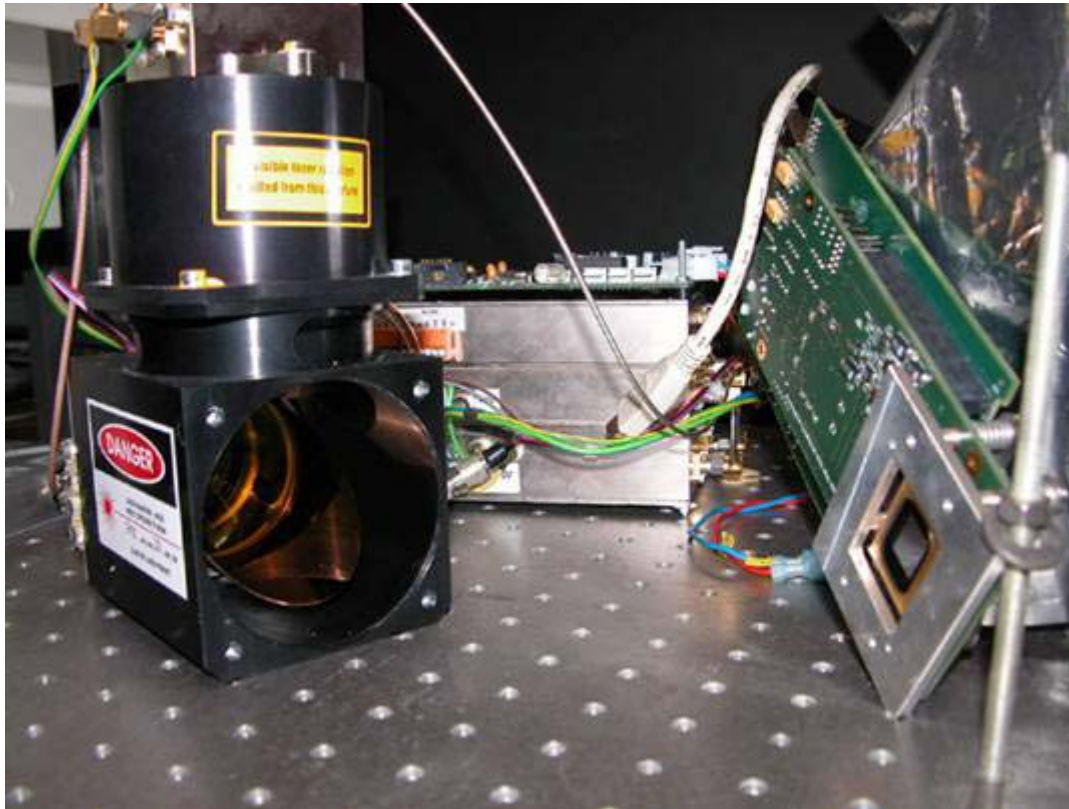
**MEMS-based beam
deflection**

**PHASER: Pico-second
High-reliability Sensor
Readout**



Next Generation LADAR

FANDANGO



**650 kHz 0-D
LADAR**

**MEMS beam
deflection**

**1×10^6
Degrees/s
Demonstrated
8/2003**

Accuracy: 3 mm

FOV: 24 deg.



LADAR Calibration Facility

- **Purpose**

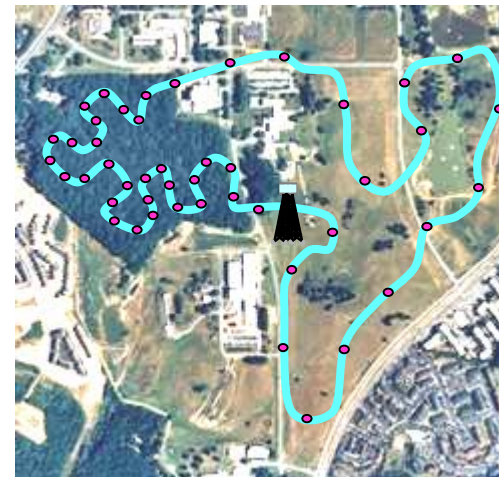
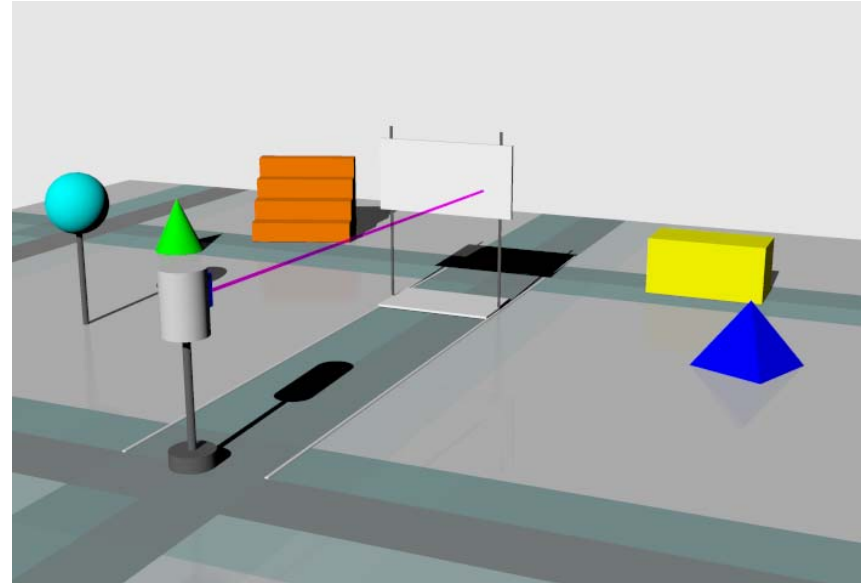
- Calibration / performance evaluation
- Test bed for developing evaluation metrics and test protocols
- Prototype instrument design

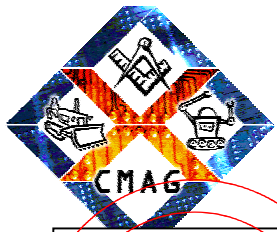
- **Indoor facility (2)**

- Climate controlled
- Artifact based

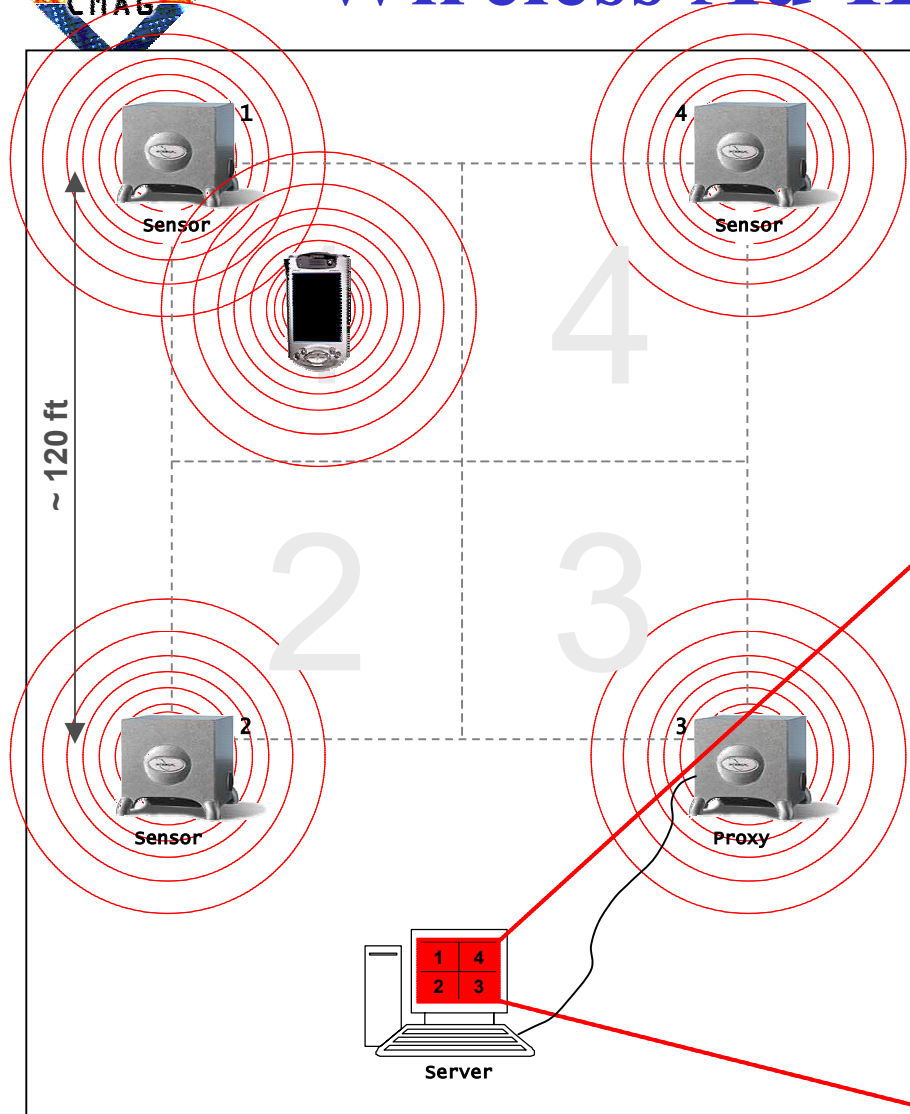
- **Outdoor facility**

- Evaluate varying terrain and environments in field conditions
- Long range calibrations

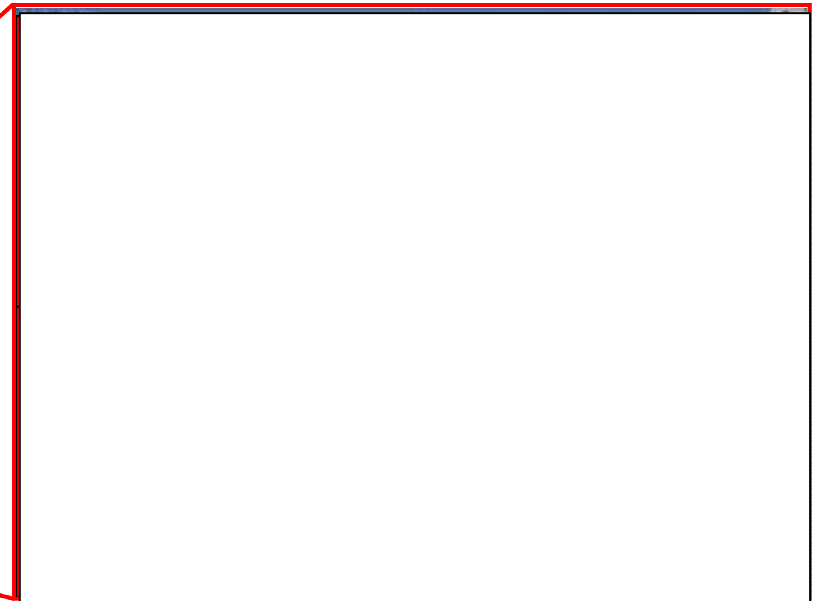


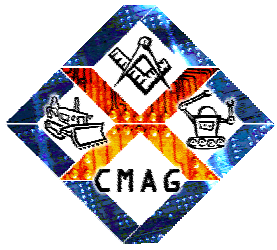


Wireless Ad-Hoc Localization



- The concept behind a grid-based localization service





Wireless Ad-Hoc Localization



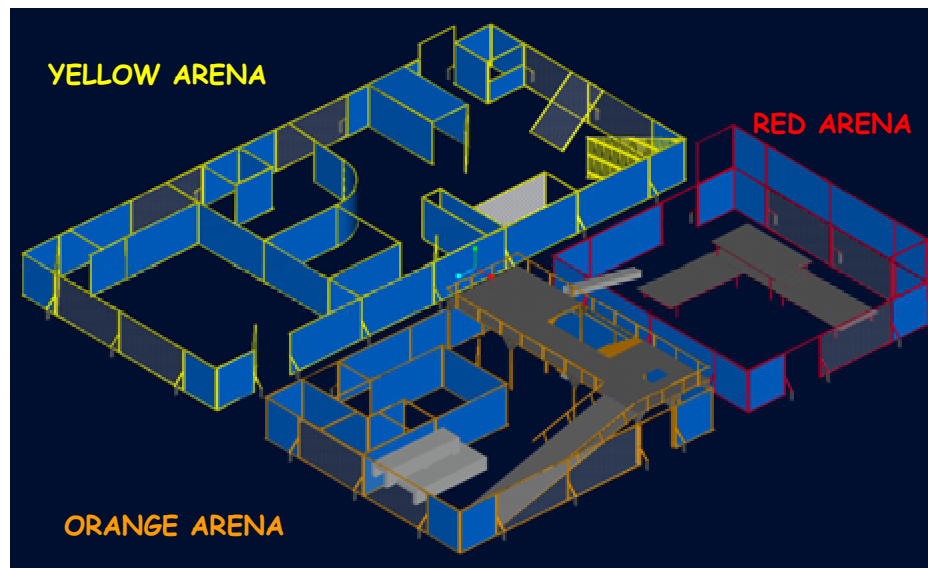
- **Localization Service**
 - Implemented Familiar-Linux on handheld computer (client being tracked)
 - Implemented Familiar-Linux on single board computers (wireless sensor “cubes”)
 - Developed software for grid-based localization
 - Demonstrated localization within a 40 m x 40 m area
- **Publications**
 - Starin, D. and Stone, W., “Wireless Ad-hoc Network for Trades Tracking”, National Institute of Standards and Technology Technical Report 7033, July 2003



RoboCup
Rescue

UWB ROBOT TRACKING

Urban Search and Rescue Test Arenas



FCC Certified*
6.0 – 6.4 GHz*
Accuracy ~ .3 m*
Stand Dev ~ .15 m*

* Man. Spec. – Multispectral Solutions, Inc.

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EM Penetration Research



Proposed Technical Approach:

Goal: Develop frequency-dependent dielectric constants for construction materials

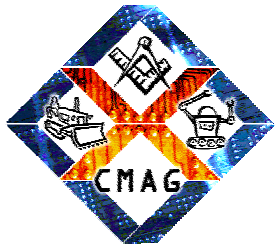
- Use existing NIST digital archive of laboratory tests (1200) conducted at NIST (1994-1997) for 27 materials
- Develop Fourier algorithms to operate on existing data
- Develop and test a 3D graphics-based tool to automatically generate a CAD model of all of the propagation characteristics for the materials likely to be present in a certain class of construction for a given tactical situation
- Validate models through field tests
- Make EM propagation models available as input to commercial-sector localization systems

Operational Capability:

Create a comprehensive digital library of experimentally-derived building material electromagnetic (EM) penetration properties that will enable the development of accurate 3D tracking systems for law enforcement and firefighting personnel operating within buildings.

Deliverables:

Digital library of EM attenuation through construction materials
Quarterly and technical reports
NIST-validated rapid infrastructure EM modeling software



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